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Noteworthy anatomical and physiological researches.

On the twisting of the grain of pine.¹

In 1854, A. Braun² published the results of extensive observations on the twisting of the grain in a large number of species of wood-producing plants, and offered an explanation for the phenomenon. The paper now under consideration contains the results of investigations on a limited number of allied species of conifers. Dr. Hartig agrees in part with Braun in his explanation, but does not agree with him as to the final cause of the twisting of the grain. The former assigns as the cause the peculiar manner in which the increase in the number of elements of the cambium occurs. As the woody axis of the tree increases in diameter the number of elements in the cambium cylinder at any height must increase correspondingly. This increase in the number of elements is secured not by division in a radial plane, but by transverse divisions. Usually these divisions do not occur at exactly a right angle to the long axis of the cell. As the two daughter cells produced by such a division, grow in length, the upper end of the lower one pushes its way upward and the lower end of the upper one grows downward, each insinuating itself between its mate and the neighboring element, separating to a slight degree the original elements of the cambium sheath, thus increasing its diameter.

These transverse walls are inclined both to the right and to the left from a radial plane. Between the relative members of these two kinds of wall and the twisting of the grain there is a close relation. Generally if the members are about equal the grain is straight. If a large majority of them incline to the right the grain winds in that direction; if to the left, the winding is in that direction. This is explained in the following manner. After each transverse division, if the wall inclines to the right, the tendency is for the upper end of the lower daughter cell to incline to the right, and for the lower end of the upper daughter cell to incline to the left. If now

¹ Hartig, Robert: Ueber den Drehwuchs der Kiefer. Forstlich-naturwiss. Zeitschrift 4: 313-326. Ag. 1895.

² Braun, A.: Ueber den schiefen Verlauf der Holzfaser und die dadurch bedingte Drehung der Bäume. Sitzber. der kgl. pr. Akad. der Wiss. Berlin, 1854.

other divisions of the elements occur in the same manner and in quick succession, the cells will all soon be inclined to the right, and in like manner if the walls incline to the left, the cells will incline to the left. The elements of the wood will be inclined as those of the cambium are inclined.

In all of the specimens examined, if any twisting of the grain occurred during the first thirty years of the life of the tree, such twisting was found to be to the left. In about half of the specimens the twisting in this direction continued throughout the life of the tree. In the other half twisting did not make its appearance until well along in the life of the plant (then to the right) or changed from the left to the right in from thirty to one hundred twenty years. The inclination of the long axis of the elements from a radial plane varied from one to ninety degrees. In a little more than half of the specimens the angle of divergence increased regularly with the age of the tree.—L. S. CHENEY.

The mechanics of curvature.

The much vexed question of the curvature of organs in response to various stimuli is again to the front, and a slight advance in the solution of the chief problem, *i. e.*, the immediate cause of the curvature, may be claimed. Noll in a recent contribution¹ meets the specific objections offered to his previous work² by Kohl³ and Pfeffer.⁴

The principal theories which have been successively advanced in explanation of curvatures are chiefly as follows: Sachs attributed it to the exaggerated growth in length of the tissues on the side whose surface became convex in outline; DeVries to an induced heightened turgor of the convex side; Wortmann, in 1887, to the thickenings of the membranes of the concave side and aggregation of protoplasm in the cells limited by them, and consequences in growth extension. In the large amount of critical work following this last contribution it was established that the migration of the protoplasm and the thickening of the membranes on the concave side were attendant upon but bore no causal relation to cur-

¹Ueber die Mechanik der Reizkrümmungen. *Flora* **81**: 36-87. 1895.

²Beitrag zur Kenntnis der physikalischen Vorgänge, welche den Reizkrümmungen zu Grunde liegen. *Arb. d. bot. Inst. z. Würzburg* **3**: 496. 1888.

³Die Mechanik der Reizkrümmungen. Marburg. 1894.

⁴Energetik der Pflanzen. *Leipsic*. 1893.—*Druck und Arbeitsleistungen durch wachsende Pflanzen*. *Leipsic*. 1893.